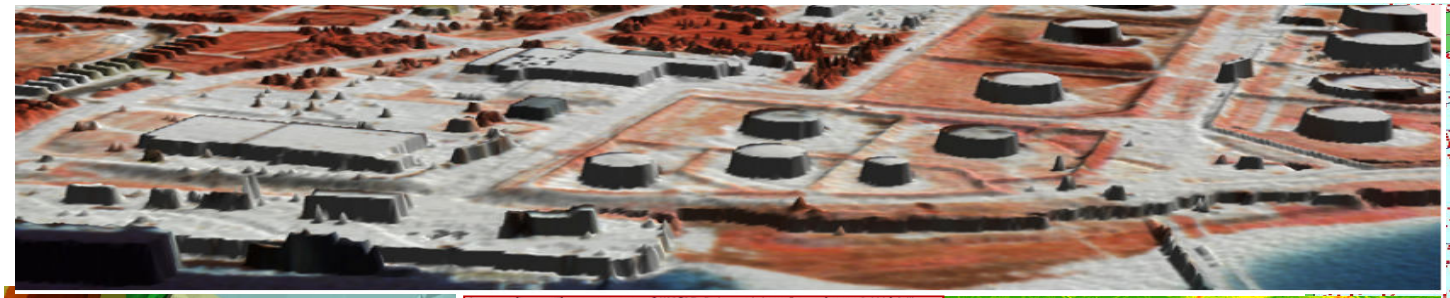

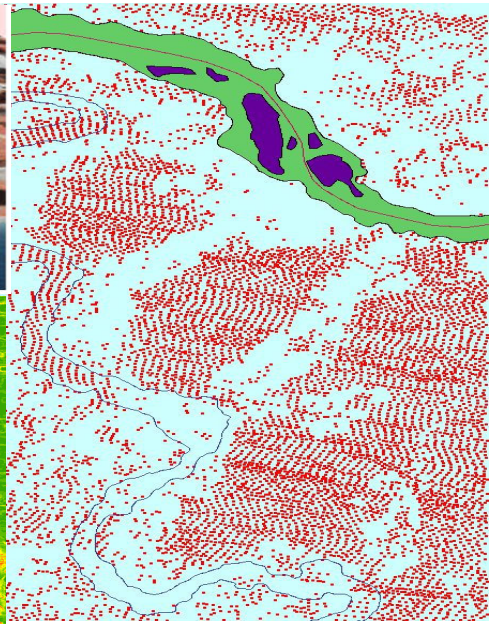

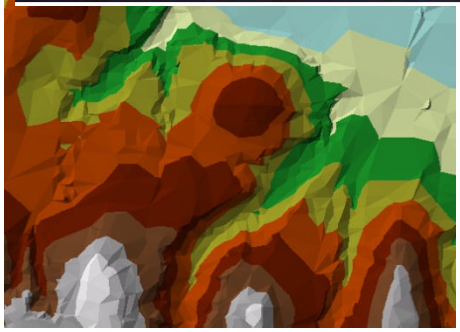

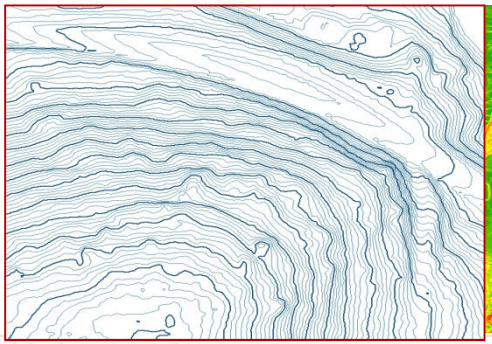

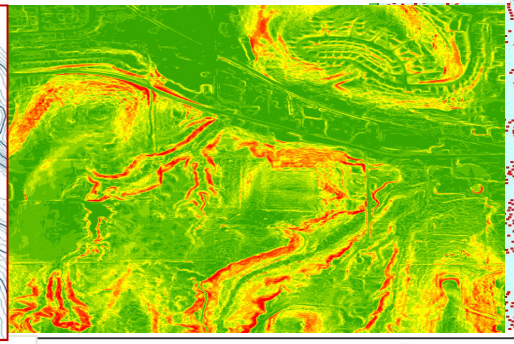

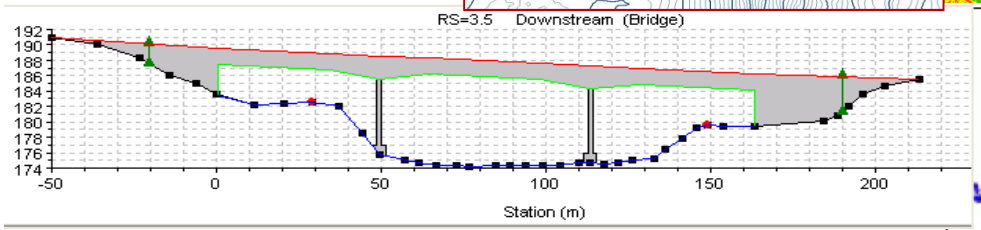

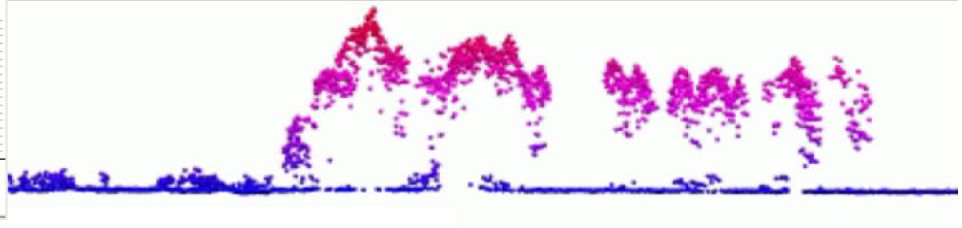

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1462208.03 1121957.34 563.94 1.7
1462208.07 1121959.93 564.07 0.4
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1462213.84 1121931.98 563.52 3.4
1462213.84 1121929.88 563.55 2.3
1462213.81 1121927.71 563.55 2.9
1462213.91 1121921.38 563.29 2.1
1462213.94 1121925.15 563.25 3.1
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1462219.88 1121942.21 563.58 3.8
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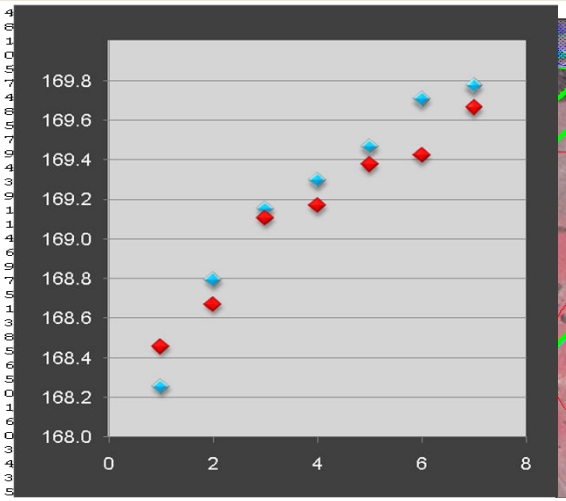
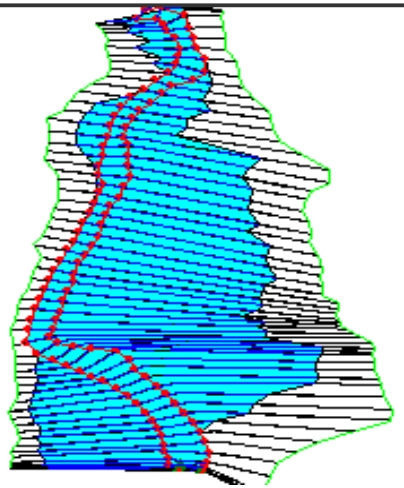




PICTOMETRY®
INTELLIGENT IMAGES

Using LiDAR to Enhance GIS Data and Aerial Imagery

Brian Garcia, District Manager Southern California
Thom Salter, Director, Mapping and Photogrammetry

November 19th, 2014

Topics

- What is LiDAR?
- Derivative Products
- Use Cases

What is LiDAR?

- **Light Detection And Ranging**
- **It is an active sensing system**
  - **It is the science of using a laser to measure distances to specific points. It uses its own energy source, not reflected natural or naturally emitted radiation**
- **It can be operated both day or night**
- **Ranging based on time difference between emission and reflection of laser pulse**
- **Direct acquisition of terrain information**

What LiDAR Is Not

NOT Light/Laser Assisted RADAR

RADAR uses electro-magnetic (EM) energy in the radio frequency range; LIDAR does not. It uses light in the near infrared spectrum.

NOT all-weather

The target MUST be visible. Some haze is manageable, but fog is not.

NOT able to "see through" trees

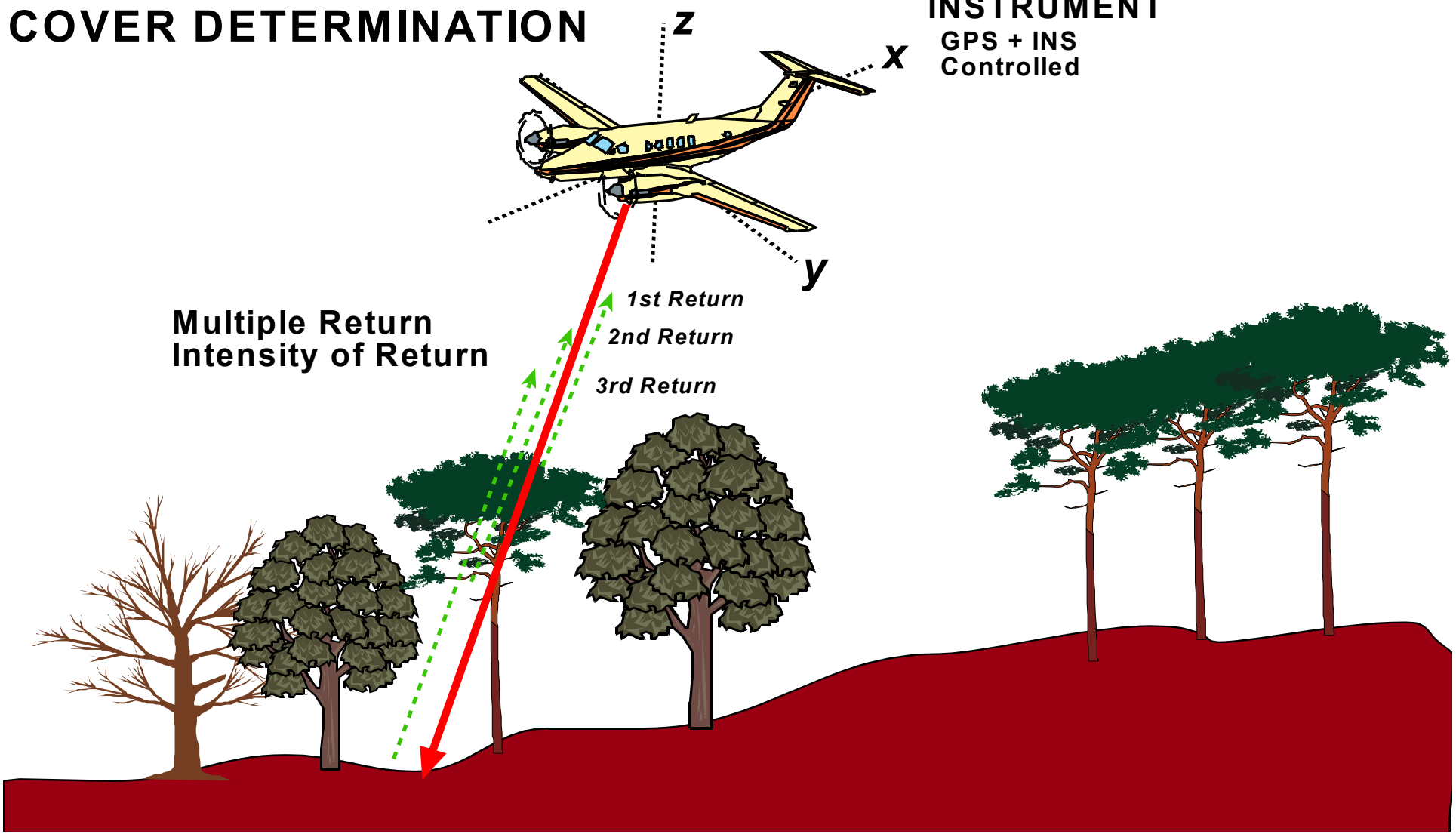
LiDAR sees around trees, not through them. Fully closed canopies (rain forests) cannot be penetrated.

NOT a substitute for photography

For MOST users, LiDAR intensity images are NOT viable replacements for conventional or digital imagery.

LIDAR HEIGHT AND COVER DETERMINATION

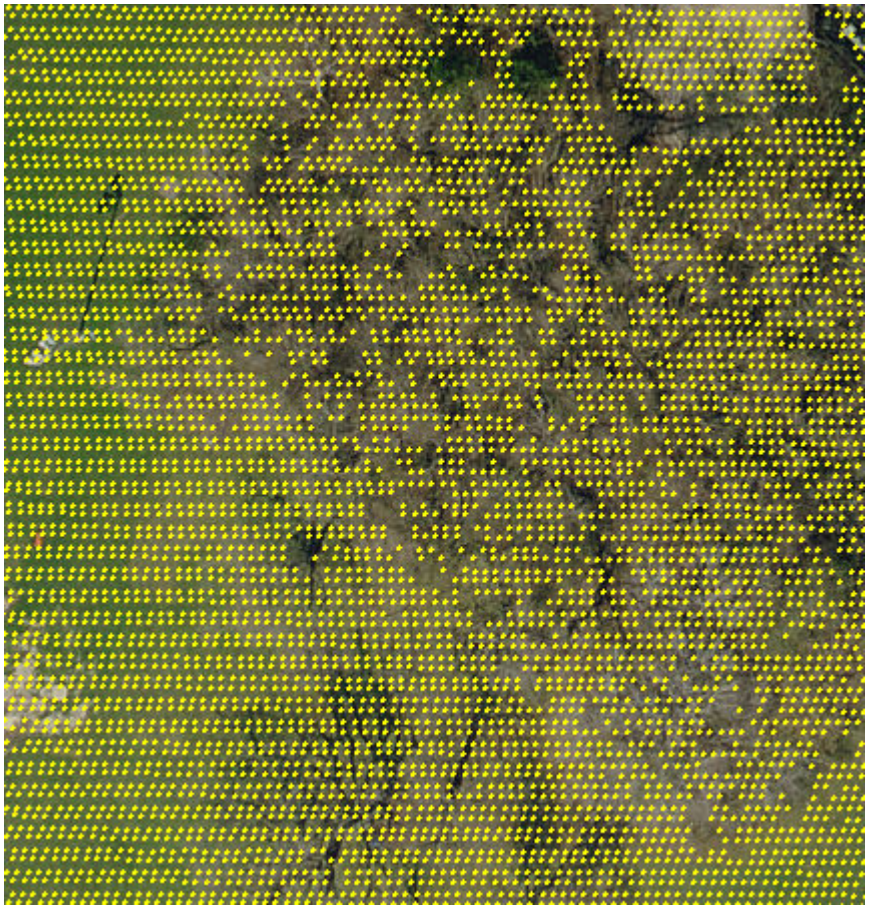
POSITION OF INSTRUMENT
GPS + INS Controlled



Sample Data

- Actual points ‘approximate’ a regular grid
  - Changes in aircraft orientation and turbulence cause variability in post spacing

Sample Data



Actual points ‘approximate’ a regular grid

- Changes in aircraft orientation and turbulence cause variability in post spacing
- Heavy vegetation will prevent some pulses from reaching ground

LiDAR Overview

Airborne Laser Mapping System

- Laser fires 100,000 pulses/sec (typical)
  - Oscillating mirror directs beam
- Reflected pulses measured
  - Duration, intensity, return count
- Position and Orientation System (POS)
  - Records position of aircraft
  - And angle of mirror
- Raw data converted to point cloud…

LiDAR Data Characteristics

How much and how accurate?

Post Spacing/Point Density

- Nominal distance between measurements
- Point count per unit area

LiDAR Data Characteristics

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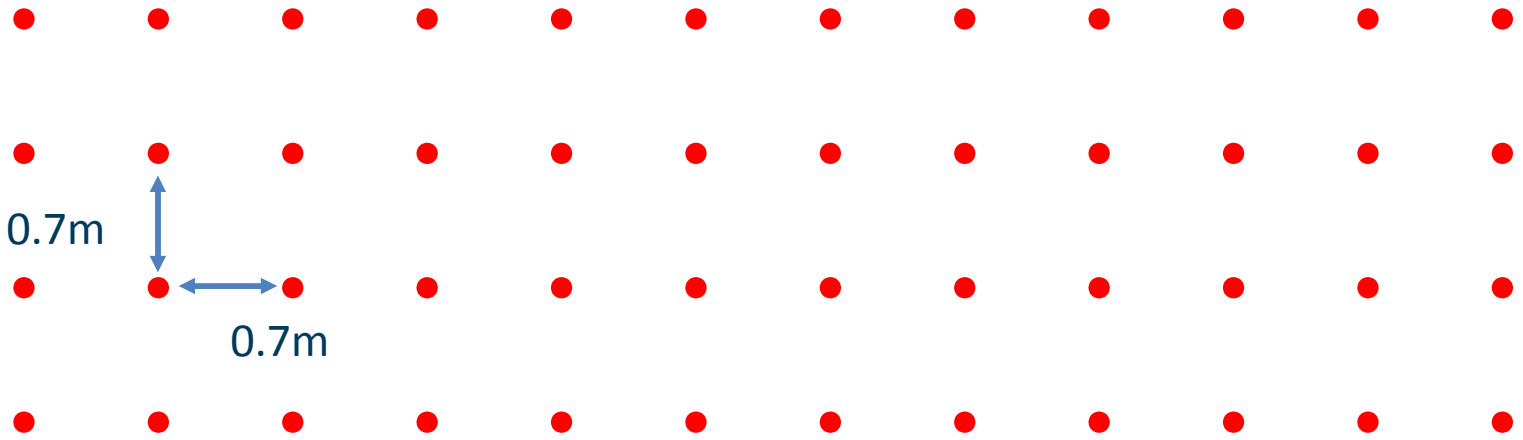
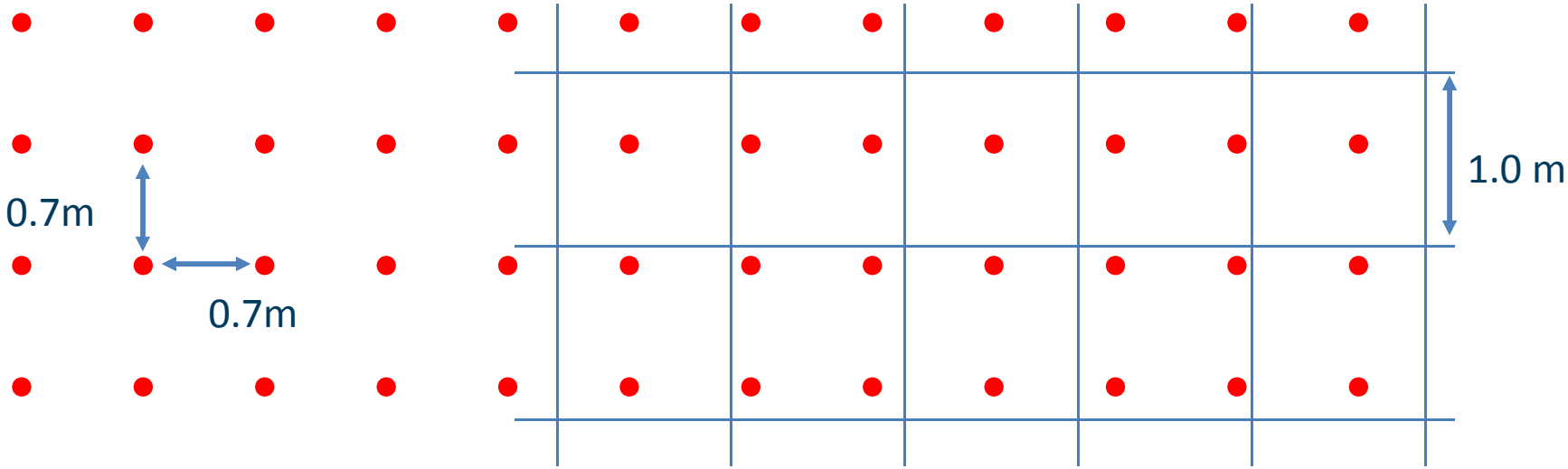


LiDAR Data Characteristics

Post Spacing/Point Density

- Nominal distance between measurements
- Point count per unit area



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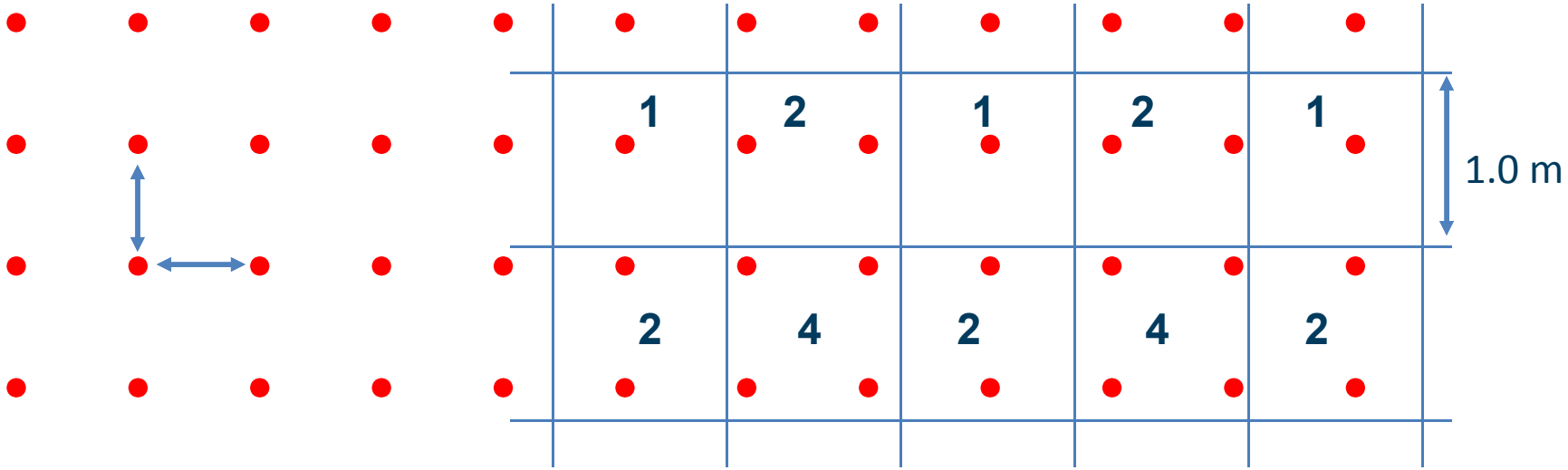
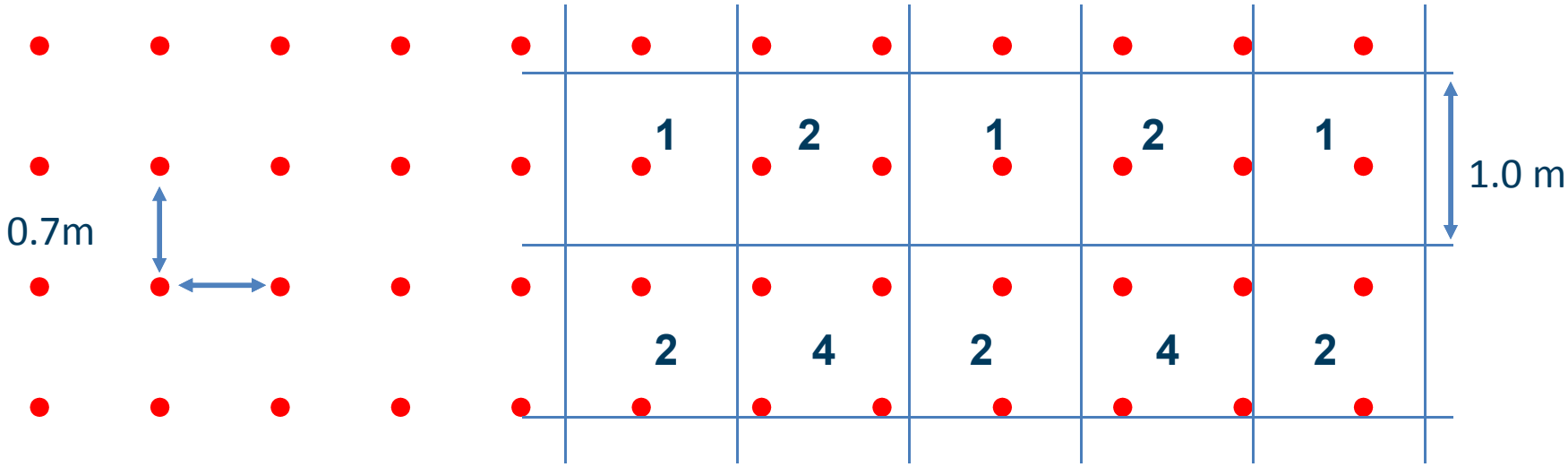


LiDAR Data Characteristics



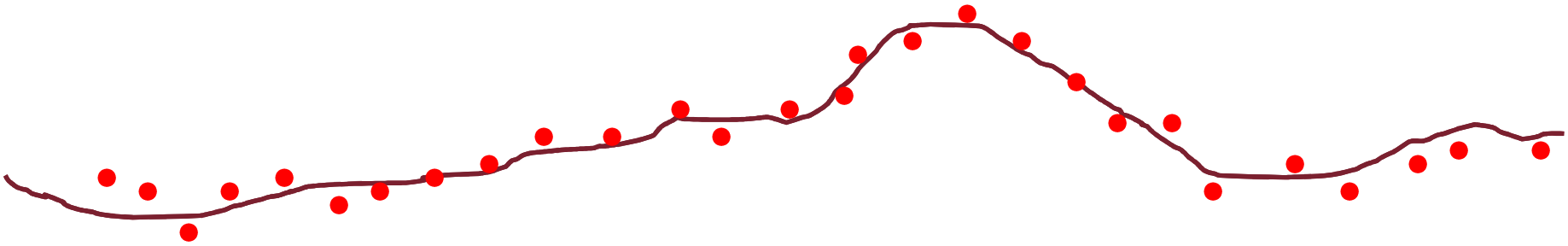
70 cm post spacing

- 21 points/10 m^2
- 2 points per m^2

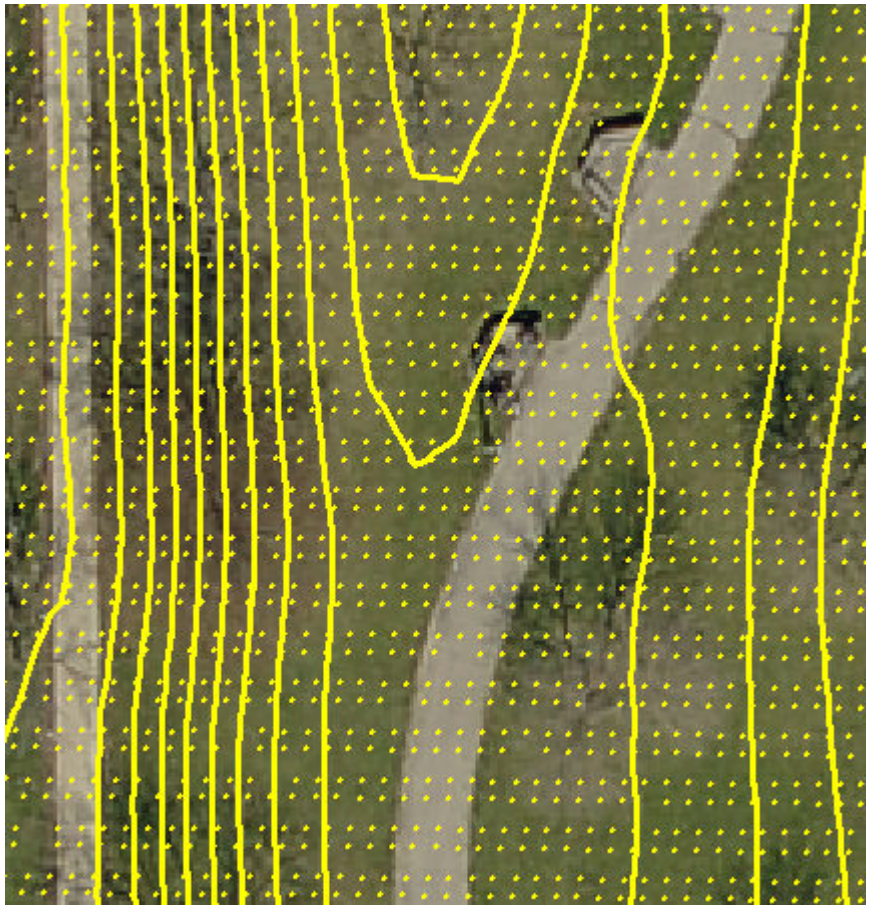
LiDAR Data Characteristics

Vertical Accuracy

- How accurate is each measurement?
- Frequently expressed as a supported contour interval



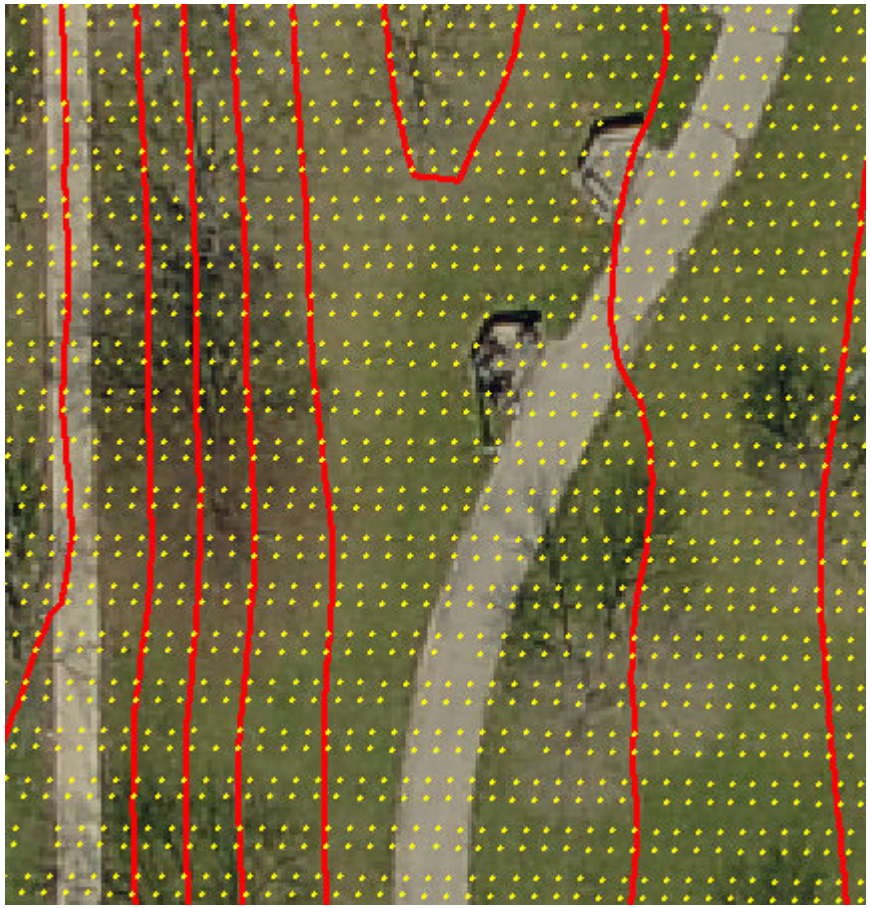
Contour Interval



90% of points within 60% of contour interval

- E.g.: 1- foot contours requires 90% of points within 7.2 inches (or 18cm)

Contour Interval



90% of points within 60% of contour interval

- E.g.: 2- foot contours requires 90% of points within 1.19ft(or 36cm)

LiDAR Collection Concepts

Mean Energy Density

- Total energy available per unit time is constant
- More pulses (per second) = Less Energy per Pulse
  - Energy <-> Accuracy
- So…
  - More pulses (per second) = less accuracy
- Primary limiting factor

Products

Operational Parameters

- Combine to optimize offerings

Standard Offering

- 1.0 m postings
- Accurate to support 2-foot contour generation
- Cost effective option
- Can meet FEMA requirements in many areas

Products

Operational Parameters

- Combine to optimize offerings

Standard Offering

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How do we upgrade?

Upgrades

Increase Point Density

- Decrease post spacing
- Fire laser more often

Upgrades

Increase Point Density

- Decrease post spacing
- Fire laser more often

Increase Point Accuracy

- Fire laser less often…

Upgrades

Increase Point Density

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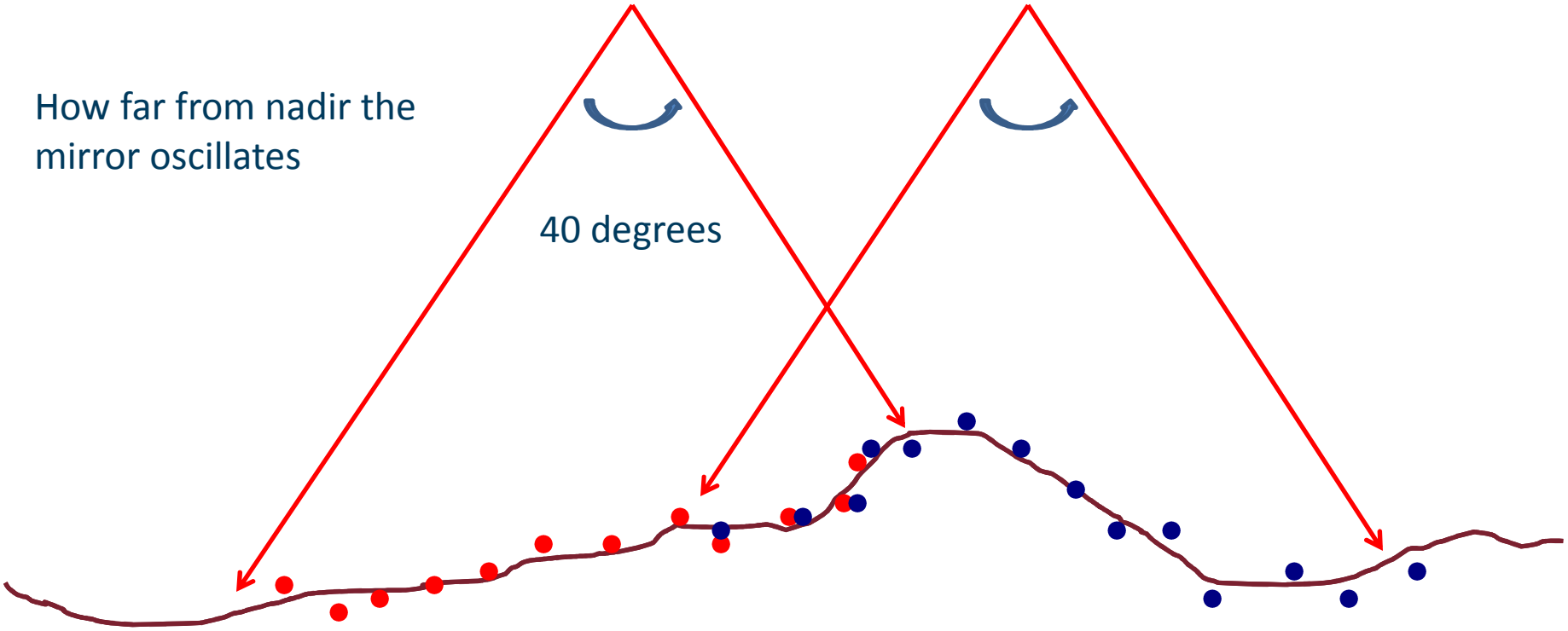
Increase Point Accuracy

- Fire laser less often…

Solution: Modify scan angle, which affects coverage, which affects cost…

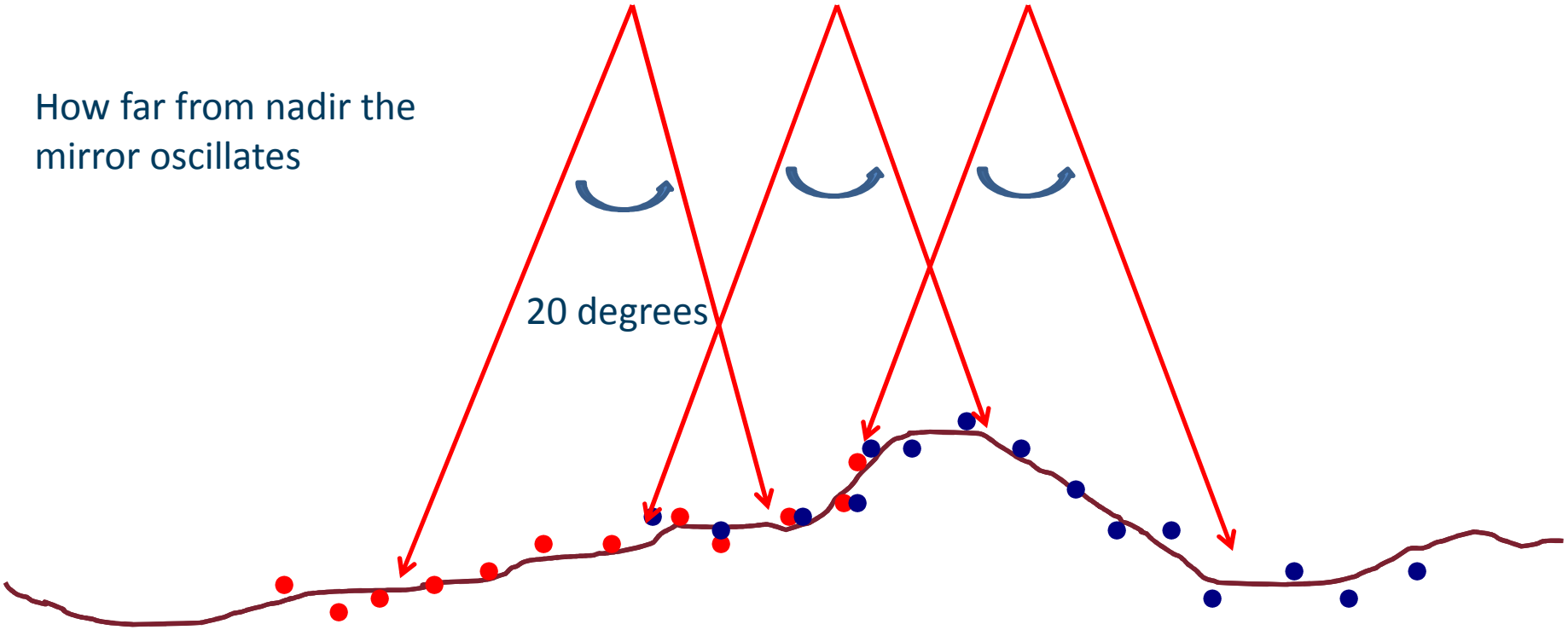
Scan Angle

How far from nadir the mirror oscillates



Scan Angle

How far from nadir the mirror oscillates



Operational Configurations

Parameter	Nominal Point Spacing		
	1.0m	0.7m	0.5m
Flight Altitude	1800m/5900ft	760m/2500ft	500m/1600ft
Point Density	1 point/m^2	2 points/m^2	4 points/m^2
Pulse Repetition Frequency	100kHz	70kHz	50kHz
Scan Angle (+/-)	16.9°	15.8°	10.1°
Scan Frequency	42.1Hz	56Hz	70.1Hz
Swath Width (raw)	1100m/3600ft	430m/1400ft	175m/475ft
Overlap	30%	30%	30%
Vertical Accuracy (bare earth)	15cm $RMSE_z$	9.25cm $RMSE_z$	9.25cm $RMSE_z$
	30cm NSSDA 95%	18.2cm NSSDA 95%	18.2cm NSSDA 95%
Horizontal Accuracy*	30cm, RMSE	20cm, RMSE	20cm, RMSE
Contour Interval Supported	2ft	1ft	1ft
Returns	*Up to four per pulse*		
Intensity Records	*Recorded for each return*		

**theoretical value per manufacturer's specification*

LiDAR Data Deliverables

LiDAR Point Cloud Data

- Tiled* LAS v1.2/3 files including Return Number and Intensity attribute for each return
  - Duplicate points and 95% of outliers removed
- Ground points classified via automated methods with manual review and clean up
  - 95% of vegetation features removed
  - 98% of buildings removed
- Buildings and vegetation not classified separately

Raw GPS/INS data and laser range files with supporting information

FGDC compliant metadata

Estimated Data Sizes (at 1.0m point spacing):

- 10-12 GB per 100 square miles (approximate)

Upgrades

One Meter → 70 cm

- Improves contour interval to 1-foot
- Important for flat areas, coastal regions

Upgrades

One Meter → 70 cm

- Improves contour interval to 1-foot
- Important for flat areas, coastal regions

70 cm → 50 cm postings

- Increase density
- Improves modeling of linear features such as edges; 3-D applications increase
- Important for vegetated areas

What Can You Do With It?

Derivative datasets

- DEM, DSM, DTM
- Breaklines (hydro and trans)
- Contours

Vegetation Analysis

Improve Imagery Accuracy

Cartography

Emergency Management

Breaklines

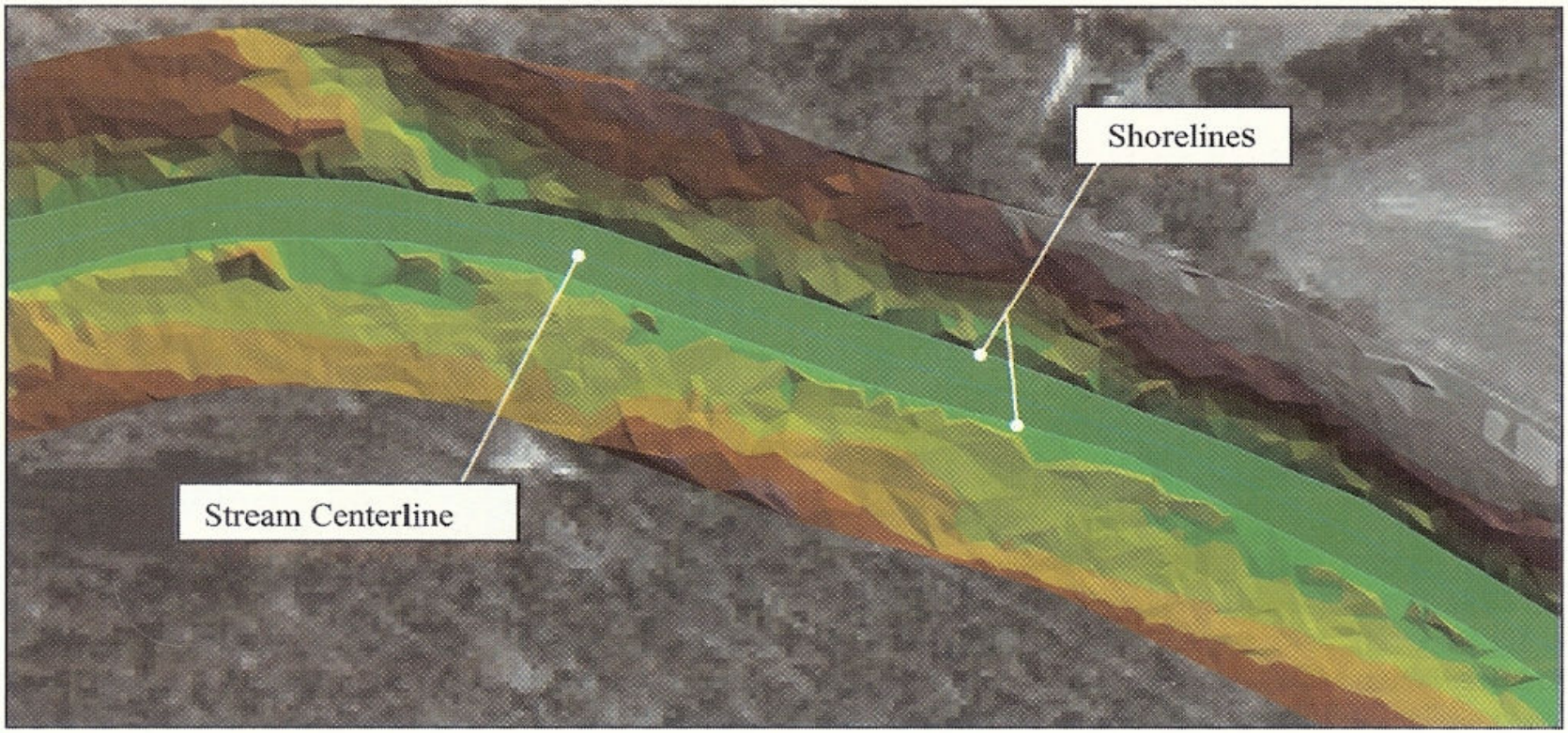


Figure 1.23 Geometric view of the same TIN, hillshaded by elevation, after breaklines are added.

Figure 1.22 Geometric view of a TIN, hillshaded by elevation, created without breaklines.

Figure 1.21 Post-processed bare-earth lidar mass points along a North Carolina stream.

Breaklines

Hyc

- **k** **age**
  f **)**
  “ **l with**
  t **r to**
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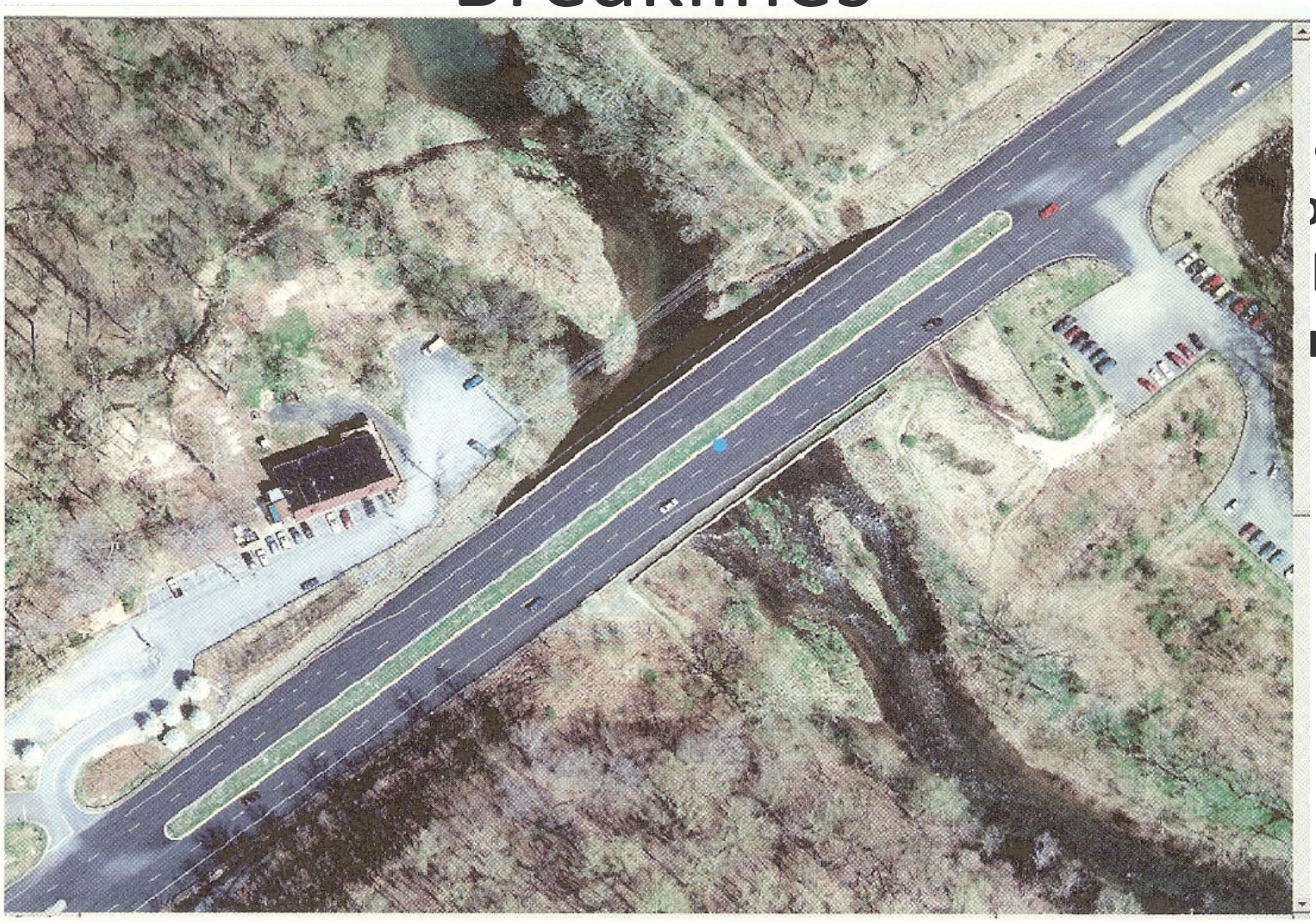
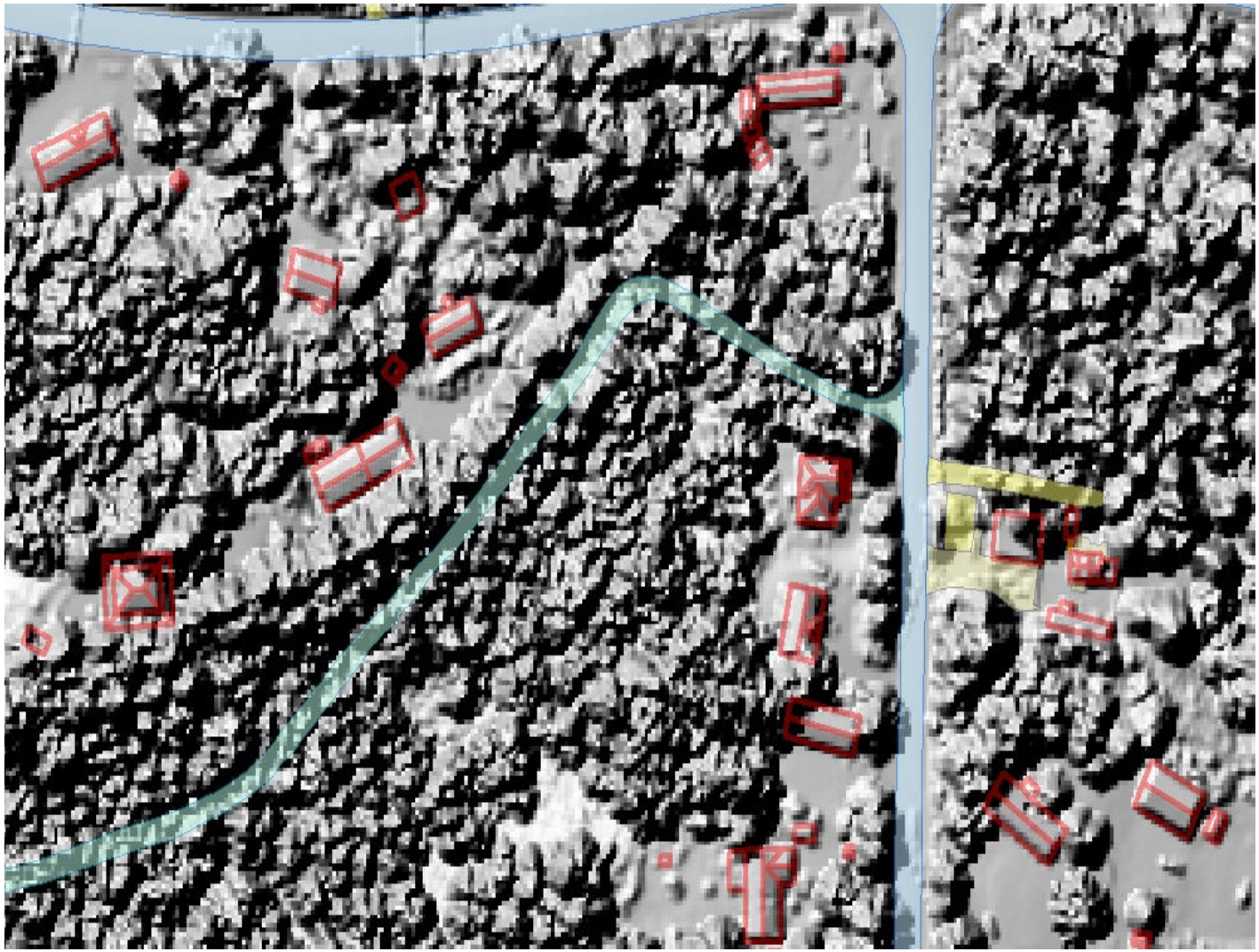


Figure 5.6 Digital orthophoto showing bridge corrected by use of DTM with breaklines. Courtesy of Dewberry.

Accuracy of Imagery


1004
1003
1001
1002

Update Base Data



Vegetation Analysis

LIDAR-Based Tree Canopy Model

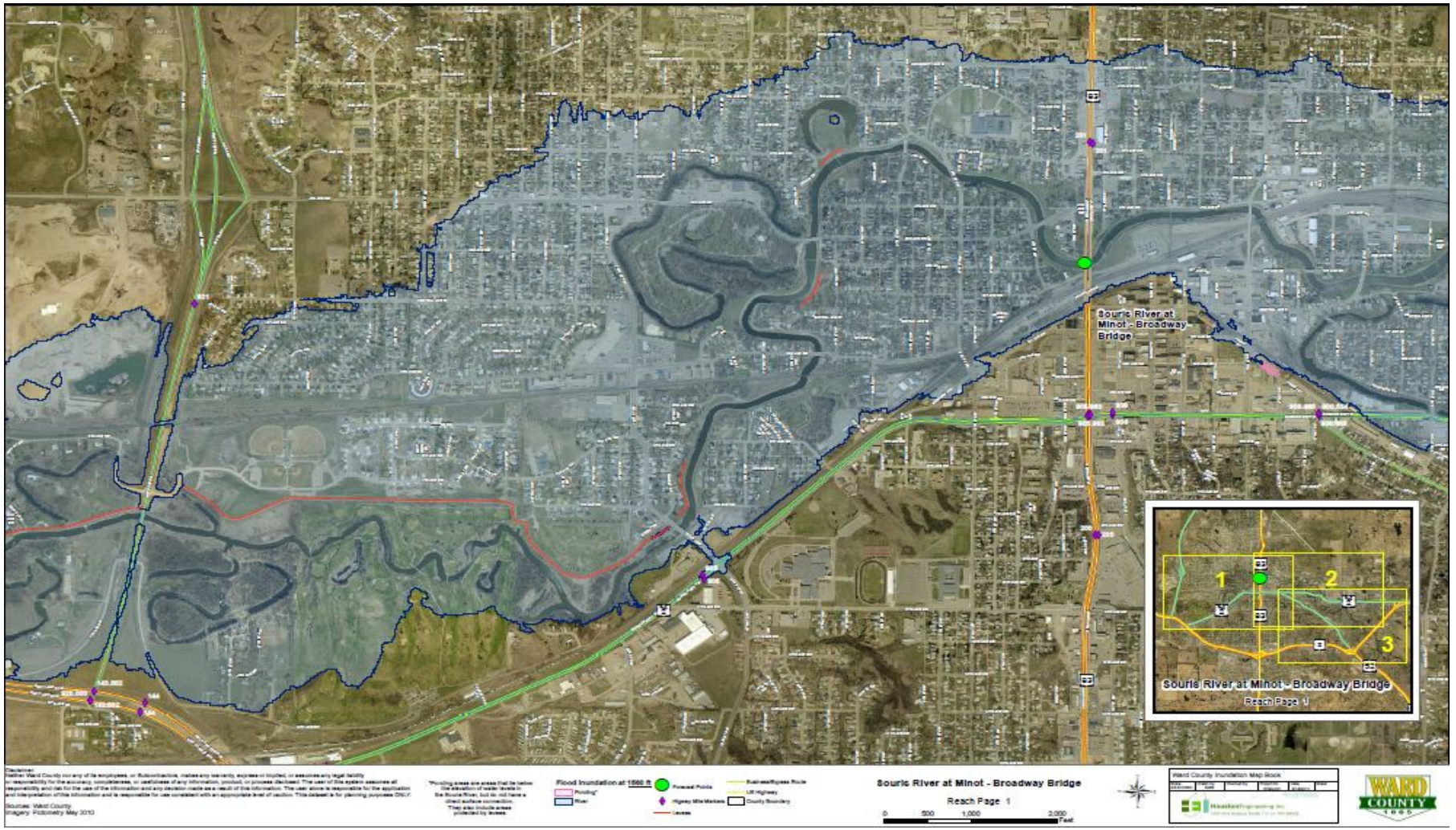
- Very Accurate Model of Tree Canopy Cover
- Spatial Analysis
  - Total Volume of Tree Canopy Cover in City
  - Volume of Tree Canopy Cover by Particular Area/Polygon
  - Identify Areas with Adequate Coverage
  - Identify Areas Lacking Adequate Coverage

Benefits of Tree Canopy Cover

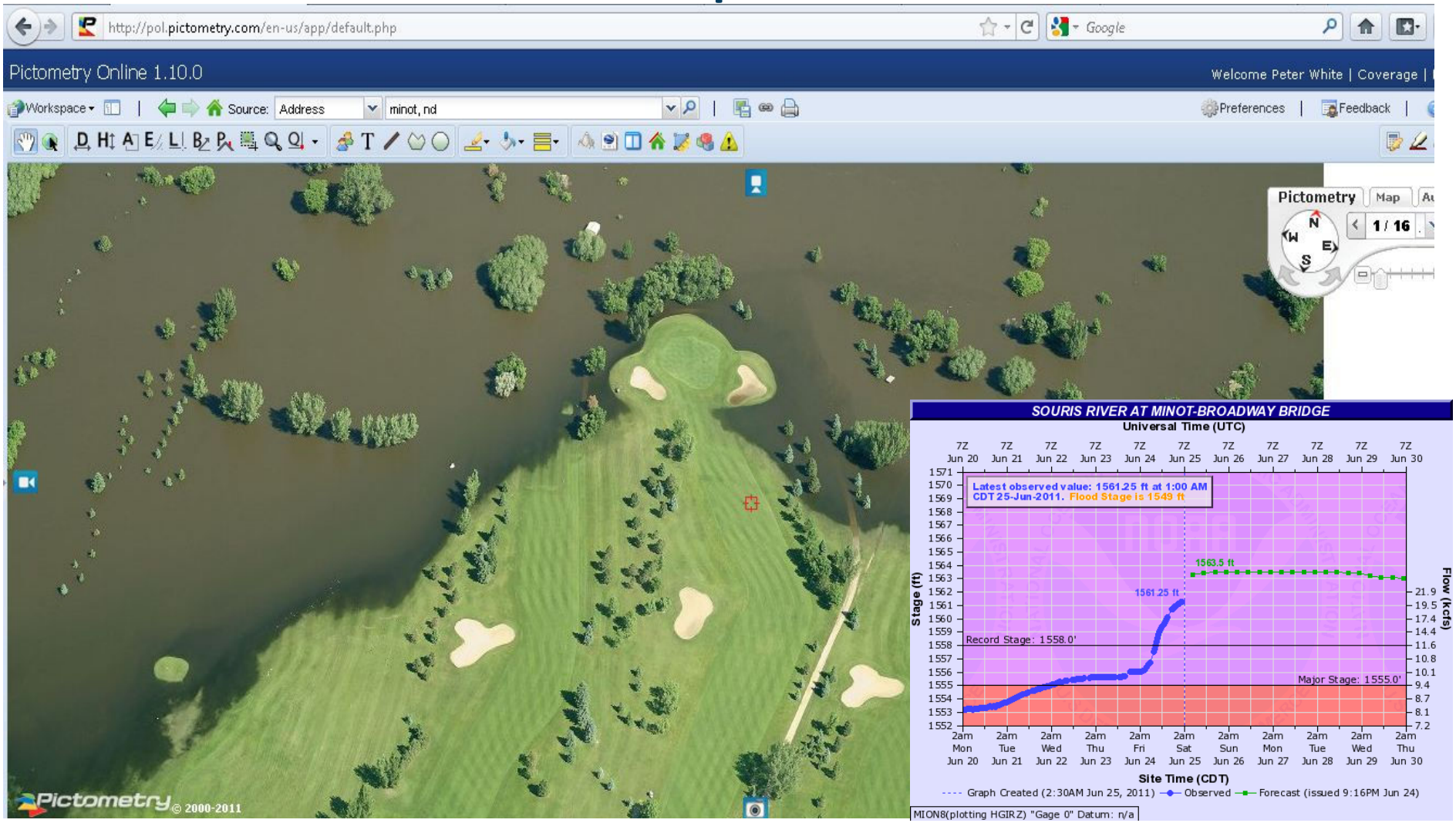
Tree Canopy – A Valuable Component of Green Infrastructure

- Reduces Energy Consumption
- Carbon Removal (Sequestration)
- Reduces Cost of Storm Water Management
- Improves Quality of Air and Water
- Reduces Noise
- Wildlife Habitat
- Psychological Benefits

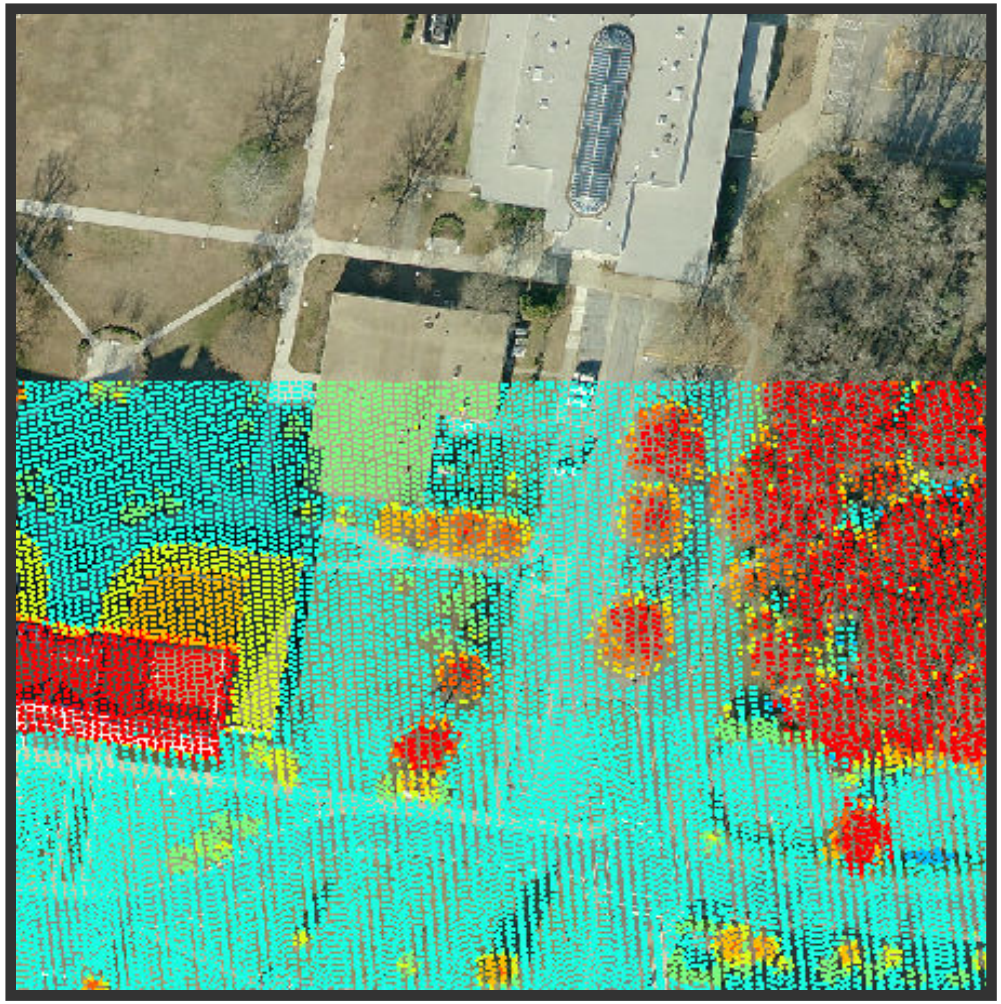
Disaster Preparedness



Disaster Preparedness



Demo



Thanks! Questions?